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'HOLY ANOREXIA' – RELEVANT OR RELIC? RELIGIOSITY AND ANOREXIA NERVOSA AMONG FINNISH WOMEN

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ABSTRACT

Objective: Since medieval times, an association between religiosity and anorexia nervosa has been suggested, but few systematic studies exist. We studied in a nationwide setting whether personal or family religiosity is associated with lifetime anorexia nervosa among women in adolescence and early adulthood. **Method:** In this nationwide study we screened women (N=2,825) from the 1975–79 birth cohorts of Finnish twins for lifetime DSM-5 anorexia nervosa (N=92). Parental religiosity was assessed by self-report when the women were aged 16 years. The women self-reported their religiosity at ages 16 and 22–27 years. **Results:** Parental religiosity did not increase the risk of lifetime anorexia nervosa, and neither did religiosity of the women themselves in adolescence. In early adulthood, a J-shaped curve was compatible with the data, indicating increased risk both at low and high levels of religiosity, but this result was statistically non-significant. Religiosity was weakly negatively correlated with body dissatisfaction. We also found suggestive evidence for socioregional variation in the association of religiosity with lifetime anorexia nervosa. **Discussion:** To our knowledge, this is the first population study to directly address religiosity and anorexia nervosa. We found no evidence for a significant association of religiosity with anorexia nervosa, either at the personal or family level, although we could not exclude regional differences nor a modest protective association of religiosity with body dissatisfaction. Despite compelling case descriptions of 'holy anorexia', religiosity does not appear to be a central factor in the development of anorexia nervosa in Finland, a highly secularized Christian country.

‘HOLY ANOREXIA’ – RELEVANT OR RELIC?

Religiosity has been associated with various forms of fasting and self-starvation for thousands of years. The founder of Jainism fasted himself to death in the 6th century BC, and Moses, Buddha, and Jesus fasted in key moments of their life[1,2]. Many early Christian saints and hermits abstained from eating as a part of ascetic-mystic practices[1].

From the 13th century, a wave of religiously motivated self-starvation swept through Europe[3–6]. This resulted in at least 100 documented cases of ‘holy anorexia’ among Italian holy women[5]. The patron saint of Italy, Catherine of Siena, was the most famous example of religiously motivated self-starvation[3–5].

From the beginning, ‘holy anorexia’ gave rise to various interpretations. Self-starvation was occasionally even interpreted as a sign of demonic possession[5]. Gradually, the practice of religiously motivated self-starvation declined[5,7]. In the 18th and 19th centuries, claims of miraculous self-starvation were often met with skepticism, because fasting was sometimes practiced for monetary gain and notoriety[1,8]. In 1873, the era of modern anorexia nervosa

began, as the syndrome was described almost simultaneously by Lasègue and Gull[9].

The intriguing historical accounts of anorexia-like symptoms among extremely religious women present the question whether 'holy anorexia' and anorexia nervosa are continuous phenomena[3,4,7]. They also imply a possible etiological connection between religious beliefs and practices and eating disorders. Putative causal mechanisms could be intrinsic, involving religiously motivated ascetic behaviors, or they could involve religiously motivated societal or family level constraints.

The potential role of individual-level religiosity in the onset of anorexia nervosa and anorexia-like syndromes is suggested by a large number of modern case studies. They demonstrate that 'holy anorexia' is not limited to past centuries: religious fasting can still trigger symptoms that resemble anorexia nervosa[10,11]. The contexts are diverse, ranging from schoolgirls fasting for religious motives in Ghana[12] to nuns in Catholic convents[11,13], and do not seem specific to any particular religion[10,13–18].

Many authors have suggested that the clash between young women adopting Western values and their traditional, religiously conservative families can increase eating disorders[19,20]. For example, among Asians living in the United Kingdom, such tensions appeared to predispose young women to eating disorders[21]. However, these studies tend to confound religiosity and culture, because they arise from settings where the religiously conservative group is also an ethnic minority. For example, in Canada, adolescent girls from the Jewish minority had more disordered eating than non-Jewish girls, but the level of religious observance was not associated with eating symptomatology[16].

Although religiosity can plausibly be seen as a risk factor for anorexia nervosa, some studies have found no associations[22,23], and many recent studies have even found inverse, protective associations. A widely held view is that Western sociocultural pressure to be thin is a key risk factor of eating disorders[19,24–27]. Religiosity can alleviate this pressure[24,28] by providing a protected environment[29] and a community of support[28]. Personal religiosity can protect from body dissatisfaction[24], provide additional coping strategies[30] and mitigate the negative mental health effects of eating disorders[31]. Further, the motives of personal religiosity may be significant[32–34].

In summary, a plethora of case studies suggest a potential connection between religiosity and anorexia nervosa, and family religiosity, particularly among immigrants and religious minorities, may also contribute to eating disorder symptoms. On the other hand, some recent evidence contradicts these connections. The existing population studies do not directly address the association of religiosity with anorexia nervosa[31,35]. Therefore, our aim was to study in a nationwide setting whether personal or family religiosity is associated with lifetime anorexia nervosa among women in adolescence and early adulthood.

METHODS

FinnTwin16 birth cohorts

This nationwide longitudinal cohort study of twins and their families[36] identified twin births in 1975–79 from the central population register of Finland. The FinnTwin16 cohort was restricted only to those pairs who both were alive at age 16 years and resident in Finland. Data collection and analysis were approved by the ethics committee of the Department of Public Health of University of Helsinki and by the Institutional Review Board (IRB) of Indiana University.

The families of the twins were approached when the twins had reached 16 years (wave 1). A returned family questionnaire implied informed consent and prompted the sending of baseline self-report questionnaires with an assessment of religiosity. Follow-up questionnaires were mailed to the twins when they were 17 years (wave 2), 18 years (wave 3), 22–27 years (wave 4) and finally 31–37 years (wave 5). Wave 4 also included an assessment of religiosity and a screen for eating disorders. The analyses in the present paper are based on female twins and their parents in waves 1 and 4 (Figure 1).

Religiosity in parents and adolescent women (age 16 years) was measured using the 12-item Religious Fundamentalism content scale of the Minnesota Multiphasic Personality Inventory (MMPI)[37,38] (Appendix A) that measures religiously motivated behaviors and religious beliefs emphasizing Christian tenets. The scores ranged from 0 to 12 and were roughly normally distributed although the father's scores were skewed to the right; higher scores reflected higher religiosity. The Cronbach's α was 0.82 for mothers, 0.85 for fathers and 0.82 for adolescent women.

Religiosity in early adulthood (age 22–27 years) was self-reported using the following multiple-choice item: "How important do you think religion is in

your life?" 1) Very important, 2) important, 3) not very important, 4) not at all important, 5) cannot tell. Because the first and last categories evoked few responses, categories 1 and 2 were merged and responses to category 5 were considered missing information. The resulting categorical variable ("religious", "not very religious", and "not at all religious") was moderately correlated with religiosity in adolescence (Kendall's tau-b = 0.41). The auxiliary religiosity variables, an aggregate measure of religiosity and formation of tertiles of religiosity are explained in Appendix B.

Eating disorder symptoms and diagnoses

In early adulthood (at age 22–27 years, mean 24.5, SD 0.9), 2,825 women (87% of the original cohort) completed a self-report screen for eating disorder symptoms[39,40]. The screen included the three subscales of the Eating Disorder Inventory 2 (EDI-2)[41]: Bulimia, Body Dissatisfaction and Drive for Thinness. (Cronbach's αs in our female sample 0.83, 0.92 and 0.87, respectively). All screen-positive women (N=292), their female co-twins (N=130), and 210 randomly selected women were invited to participate in diagnostic telephone interviews conducted using the Structured Clinical Interview for DSM-IV (SCID)[42]. Four MDs and one registered nurse from the Eating Disorder Unit of Helsinki University Central Hospital interviewed 86.7% of the eligible participants[39,40].

After the publication of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) in 2013, four experienced MDs recoded the interviews and established consensus DSM-5 eating disorder diagnoses. Age of onset of symptoms and recovery status were also determined on the basis of the interviews[43,44].

In total, 92 women fulfilled DSM-5 criteria for lifetime anorexia nervosa. Women who were not diagnosed with any eating disorder and who did not have a twin sister with an eating disorder were considered healthy women (N=2,556). Five of the women with lifetime anorexia nervosa were among the 180 randomly selected women who were interviewed. Therefore, there most likely were some women with undetected anorexia nervosa among those considered healthy.

Education and place of residence were considered as potential confounders and effect modifiers[38,45,46]. Education in early adulthood was analyzed in two categories: non-academic education (compulsory education only or vocational secondary education) vs. academic education (academic secondary education (high-school) or tertiary education (college, university)).

Place of residence in adolescence was available from the last year of wave 1[47] and was divided into Southern Finland and Northern Finland[38,48]. Southern Finland is less religious and more densely populated than Northern Finland[38], but both urban and rural areas exist both in Southern and Northern Finland. Place of residence in early adulthood was available from self-reports, and was analyzed in two categories: 1) urban areas (capital area and cities with at least 20,000 inhabitants) and 2) rural areas (including small towns).

Datasets and multiple imputation

A detailed description of the datasets and the multiple imputation process can be found in Appendix B. In short, because our data consists of twins, we divided each twin pair to two separate datasets (dataset A and dataset B). After exclusion of women with missing information on anorexia nervosa status and the few women living on the Åland Islands[38], dataset A consisted of 1312 women of whom 38 were affected by lifetime DSM-5 anorexia nervosa, and dataset B consisted of 1327 women of whom 53 were affected by lifetime DSM-5 anorexia nervosa.

We used substantive-model compatible fully conditional specification (SMC-FCS) multiple imputation to impute missing covariates for main

analyses[49,50]. A separate substantive model, and thus a separate multiple imputation, was used for the analyses where the outcome was restricted to DSM-5 anorexia nervosa with age of onset >16 years. Additional analyses concerning currently symptomatic women, place of residence in early adulthood and EDI-2 subscales in early adulthood were based on complete cases after stepwise deletion in datasets A and B because of sparse data or limited number of substantive models supported by the SMC-FCS multiple imputation statistical package. However, there were few missing values in these variables.

Statistical analysis

We used logistic regression to model the relationship between religiosity and anorexia nervosa. We combined the point estimates and their 95% confidence intervals across imputations using Rubin's rules[51,52]. We repeated the same analyses separately in both datasets to see if our results can be replicated. Further, we used Kendall's tau-b and Spearman's rank correlation coefficients to assess correlations, linear regression to compare means, and multinomial logistic regression to assess change in religiosity (Appendix B). We used the statistical software package Stata 13 in all analyses, and all p-values and confidence intervals are two-sided. The p-values are rounded upwards.

RESULTS

Parental religiosity

Overall, mothers were more religious than fathers ($p<0.001$ in both datasets, Table 1). Neither high religiosity of mothers nor high religiosity of fathers predicted lifetime DSM-5 anorexia nervosa among their daughters (Figure 2).

We also tested the joint effect of the religiosity of both parents by comparing families where both parents were in the highest tertile of religiosity to families where both parents were in the lowest tertile of religiosity. Yet, we found no evidence for an increased risk of anorexia nervosa among the daughters of the most religious families (results not shown).

Personal religiosity in adolescence

Religiosity in adolescence was not associated with lifetime DSM-5 anorexia nervosa (Figure 2). To gain a prospective perspective, we restricted the analyses to women whose symptoms of anorexia nervosa appeared after the baseline measurement of religiosity at age 16 years; the odds ratios increased a

little, but no evidence for an increased future risk of DSM-5 anorexia nervosa associated with religiosity was found (Figure 2).

To assess the effects of very high religiosity, we also contrasted the most religious decile to the rest of the women. The odds ratios for lifetime DSM-5 anorexia nervosa for the most religious decile were 0.62 (95% confidence interval (CI) 0.09-4.26) and 0.36 (95% CI 0.05-2.45) in Datasets A and B, respectively.

Personal religiosity in early adulthood

Personal religiosity in early adulthood (age 22–27 years) had a J-shaped association with lifetime DSM-5 anorexia nervosa, but this finding was not statistically significant (Figure 3). Adjustment for education (non-academic vs. academic) left these results virtually unchanged.

To reduce the potential impact of retrospective diagnostic assessment, we conducted a subgroup analysis contrasting *currently symptomatic women* with healthy women. The results suggest that currently symptomatic women may be less religious than healthy women (Appendix C). In comparison to healthy women, those who were currently symptomatic in early adulthood had lower

religiosity already in adolescence, but the estimates were imprecise (Appendix D).

Eating Disorder Inventory 2 in early adulthood

We assessed the cross-sectional association of religiosity with eating disorder symptoms (as measured by the EDI-2) in early adulthood. In dataset A, the Spearman's rank correlation coefficient between religiosity and Bulimia was 0.010 (p=0.73), religiosity and Drive for Thinness 0.0083 (p=0.78), and religiosity and Body Dissatisfaction -0.082 (p=0.005). In dataset B, the Spearman's rank correlation coefficients were: religiosity and Bulimia -0.011 (p=0.70), religiosity and Drive for Thinness 0.0025 (p=0.94), and religiosity and Body Dissatisfaction -0.054 (p=0.06).

Socioregional differences

We studied interactions with areas of residence. *In wave 1*, we contrasted Northern Finland with Southern Finland to see whether a more religious cultural environment changed the relationship between parental religiosity and offspring anorexia nervosa. These analyses yielded suggestive evidence for socioregional differences in the association of paternal and maternal religiosity with the risk of anorexia nervosa (Appendix E).

In adolescence, personal religiosity was not associated with anorexia nervosa in either Northern or Southern Finland (Appendix E). *In early adulthood*, however, we found that in rural areas of Finland, 70% of women with lifetime DSM-5 anorexia nervosa were religious; none of them were not at all religious. This finding was in contrast to the urban areas, where the results were comparable to the main analysis: a J-shaped association was observed (Appendix F).

DISCUSSION

Compelling medieval descriptions of 'holy anorexia' and many modern case studies of religious fasting suggest an etiological connection between religiosity and anorexia nervosa, but few systematic studies have examined this question in the population. We conducted a nationwide study to assess the connection between personal and family religiosity and lifetime DSM-5 anorexia nervosa and eating disorder symptoms among women in a highly secular context of present-day Finland, where our measures of religiosity mainly reflected Christian religion. Our study found no evidence that either higher

personal or parental religiosity is significantly associated with lifetime anorexia nervosa in our population-based Finnish twin cohort.

The association of religiosity in early adulthood with lifetime DSM-5 anorexia nervosa showed a J-shaped curve. However, this finding was not statistically significant, and when we analyzed the risk of lifetime anorexia nervosa by tertiles of religiosity in early adulthood, the J-shaped curve was not replicated (Appendix G). Religiosity in adolescence did not increase the risk of lifetime DSM-5 anorexia nervosa. Nor did religiosity in adolescence increase the risk of anorexia nervosa onset in the future. Further, of the subscales of the Eating Disorder Inventory 2, Bulimia and Drive for Thinness were not correlated with religiosity in early adulthood, and Body Dissatisfaction had rather a negative than a positive correlation with religiosity. Combining these evidence, personal religiosity does not seem to increase the risk of anorexia nervosa.

Our findings do not contradict the few modern population studies conducted to date. Religiosity and eating disorder symptoms were not directly associated in Canada[35], whereas a large USA-based study found that religiosity might have a beneficial effect on mental health: religious attendance and prayer mitigated the negative effects of eating disorders on self-esteem[31]. Evidence from

other recent studies is mixed: some found no connection between religiosity and disordered eating[16,22,23], others suggest that religiosity may protect from body dissatisfaction and eating disorder symptoms[24,28,29], and a further two suggest the opposite[53,54]. In summary, our findings add to the evidence that overall religiosity is not a central risk factor for anorexia nervosa.

When comparing our results to historical case reports, it is crucial to acknowledge the importance of the relevant religious, cultural and social context. The case reports of 'holy anorexia' are from a time, place, culture and society that is very different from ours. Religiosity in the Middle Ages may have had important differences with modern religiosity, and the women with 'holy anorexia' were Catholic, not Protestant.

It is also important to note the anecdotal nature of evidence stemming from case reports, be they modern or medieval. Because systematic population studies from the Middle Ages are lacking, the prevalence of 'holy anorexia' among highly religious medieval women remains unknown. It is also difficult to differentiate the effects of religiosity from the effects of other factors. For example, the onset of 'holy anorexia' of Saint Catherine of Siena coincided with her efforts to avoid a marriage that was arranged against her will[5]. Further, it may be hard to determine whether 'holy anorexia' was etiologically more about religiosity

that was expressed as self-starvation or self-starvation that was expressed religiously.

If the religious, cultural and social context was important in the Middle Ages, so it is today. Hence, our results need to be interpreted in their proper context. Overall, Finland is ethnically highly homogenous and largely Protestant, but has secularized quickly[55]. Three quarters of the Finns are members of the Lutheran church[56] and few Finns belong to other Christian denominations or non-Christian religions. Both fasting and extremism are rare in Finland. Therefore, our study mostly describes moderate Protestant Christian religiosity in a modern, secular context. Extreme religiosity may also be qualitatively different from the high religiosity assessed in the present paper. Further, our results might not generalize to other Christian denominations or non-Christian religions, or to other cultures, societies or times. Despite our negative findings, religiosity may be associated with anorexia nervosa in other contexts[57,58].

We assessed the possible effect measure modification by the religious and social context in our interaction analyses. They suggested that socioregional differences in the association between religiosity and anorexia nervosa may exist. Unfortunately, we were unable to replicate these findings as our measures of place of residence differed between study waves.

Some factors that could have affected our findings need to be acknowledged. First, retrospective diagnostic assessment can introduce information bias. To reduce this risk, we analyzed a subsample limited to currently symptomatic women. We found that, when compared to healthy women, women currently symptomatic with anorexia nervosa were rather less religious than more religious. This means that it is unlikely that a positive connection between religiosity and anorexia nervosa was masked by information bias.

Second, our measures of religiosity have important limitations. Direct comparison between the study waves was not possible. In adolescence, and among parents, we had a 12-item measure focusing on Christianity, and we also analyzed the most religious decile of adolescents, but these measures did not measure religiosity that does not adhere to Christian tenets. In early adulthood, however, our measure was crude having only a single item and three categories. It was not specific to any religion, and the distribution was severely limited with few highly religious women. If religion-specific effects existed, in adolescence we captured those specific to Christianity, but in early adulthood a mixture of

heterogeneous effects. We also had no information on the motives of personal religiosity[32–34].

Third, it is known that religiosity can change over time[59]. A severe illness like anorexia nervosa may have an impact on religiosity[60,61] or on the religiosity of the parents of the affected individual. We indirectly tested this in our data, but found no evidence for an increased change in religiosity between study waves among those affected by lifetime anorexia nervosa (Appendix H).

Fourth, missing data on religiosity may introduce bias. We used multiple imputation to reduce the potential impact of missing information. We included auxiliary variables to increase the plausibility of the missing at random assumption. Furthermore, the results from multiple imputation and complete case analysis were close to each other.

Fifth, despite nationwide sampling and high participation rates, the number of women with lifetime anorexia nervosa was relatively small and statistical power to detect small associations was limited, particularly for subgroup analyses: the lack of statistically significant associations cannot

necessarily be interpreted as lack of true associations. Similarly, occasional statistically significant associations may be found by chance alone.

We believe that the weaknesses of our study are offset by its important strengths. We assessed religiosity and anorexia nervosa in a large, population-based, nationwide cohort. The relative homogeneity of the Finnish population reduces the confounding effect of minority cultures. We measured religiosity in two time points and the Religious Fundamentalism content scale of the Minnesota Multiphasic Personality Inventory is well-validated[37]. In contrast to earlier research, we did not rely on symptom scores only but had actual anorexia nervosa diagnoses by expert clinicians.

Conclusions

In this population-level study among Finnish women, we studied religiosity and anorexia nervosa in a highly secular context where our measures of religiosity mainly reflected Christian religion. We did not find a significant connection of religiosity with anorexia nervosa either at the personal or family level. However, regional differences may exist, and we could not exclude the possibility that religiosity might have a small positive effect on body image. Despite compelling case descriptions of 'holy anorexia', religiosity does not

appear to be a central factor in the development of anorexia nervosa in present-day Finland, a highly secularized Christian country.

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1 Table 1. Characteristics of the data.

	Dataset A				**Dataset B**			
	N	**Mean**	**95% CI**	**SD**	**N**	**Mean**	**95% CI**	**SD**
Maternal religiosity	1312	5.0	4.9–5.2	2.9	1327	5.1	4.9–5.3	3.0
Paternal religiosity	1312	3.9	3.7–4.1	3.1	1327	3.9	3.6–4.1	3.1
Religiosity in adolescence	1312	4.5	4.3–4.6	2.9	1327	4.4	4.2–4.6	2.9
	Dataset A				**Dataset B**			
Religiosity in early adulthood	**N** (estimated from multiple imputation)*		**Proportion** (of total N 1312)	**95% CI**	**N** (estimated from multiple imputation)*		**Proportion** (of total N 1327)	**95% CI**
-not at all religious	302		0.23	0.21–0.25	290		0.22	0.20–0.24
-not very religious	620		0.47	0.45–0.50	649		0.49	0.46–0.52
-religious	389		0.30	0.27–0.32	389		0.29	0.27–0.32
Place of residence in								

adolescence						
-Northern Finland	578	0.44	0.41–0.47	586	0.44	0.41–0.47
-Southern Finland	734	0.56	0.53–0.59	741	0.56	0.53–0.59
Education in early adulthood						
-non-academic	499	0.38	0.35–0.41	493	0.37	0.35–0.40
-academic	813	0.62	0.59–0.65	834	0.63	0.60–0.65
Place of residence in early adulthood	**N** (available for analysis)	**Proportion** (of total N 1227 available for analysis)		**N** (available for analysis)	**Proportion** (of total N 1247 available for analysis)	
-rural areas	286	0.23		311	0.25	
-urban areas	941	0.77		936	0.75	
Age of onset of anorexia nervosa	**N**	**Proportion** (of total N 38)		**N**	**Proportion** (of total N 53)	
≤16 years	15	0.39		24	0.45	
> 16 years	23	0.61		29	0.55	

Legend: Maternal religiosity, paternal religiosity and religiosity in adolescence measured on the Religious fundamentalism content scale of the Minnesota Multiphasic Personality Inventory when the women were 16 year adolescents. Religiosity in early adulthood measured when the women were 22–27 years old. 95% CI, 95% confidence interval; SD, standard deviation. *Numbers may not add up to total N because of rounding.

Figure 1. Flowchart of the study cohort

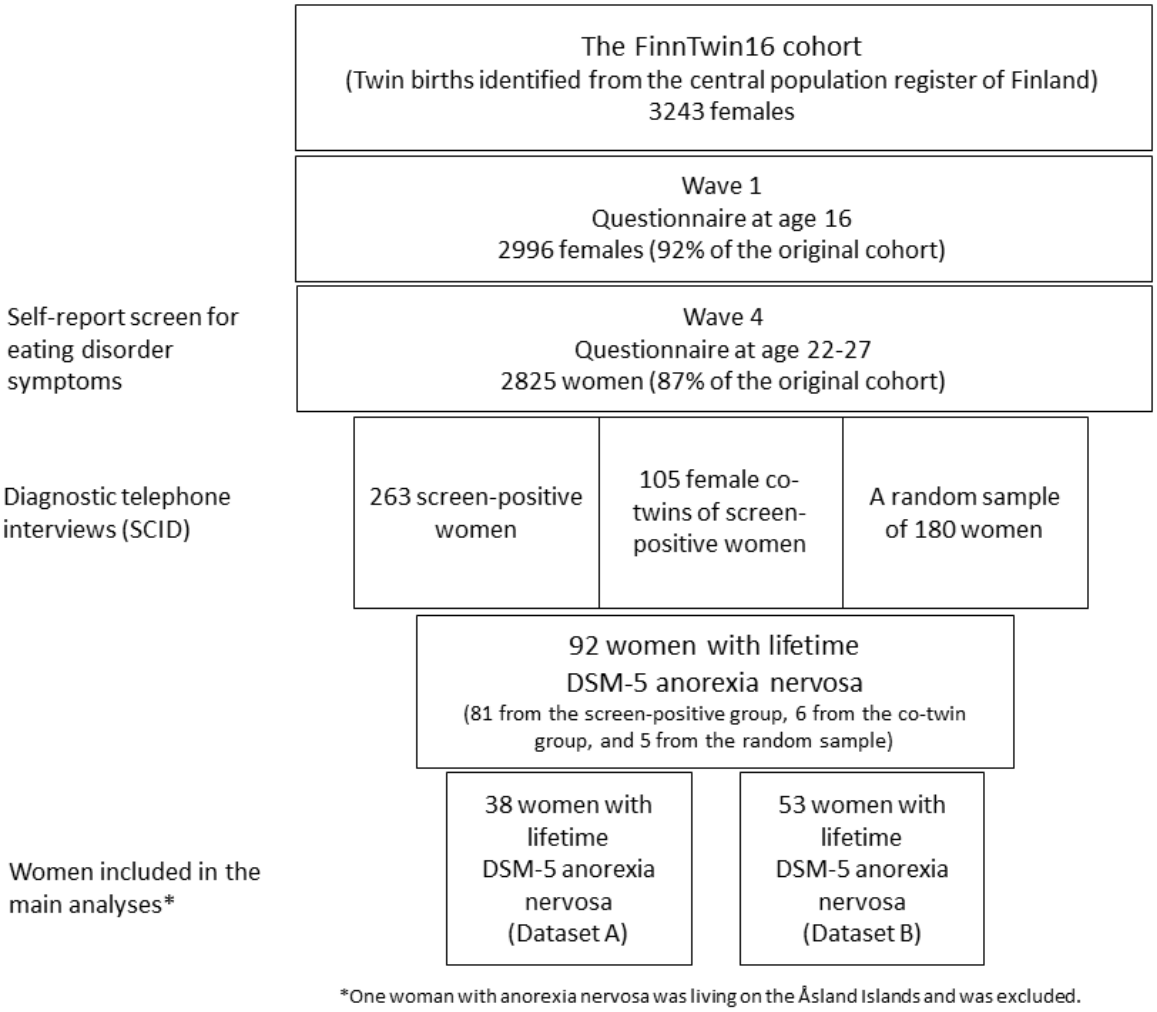
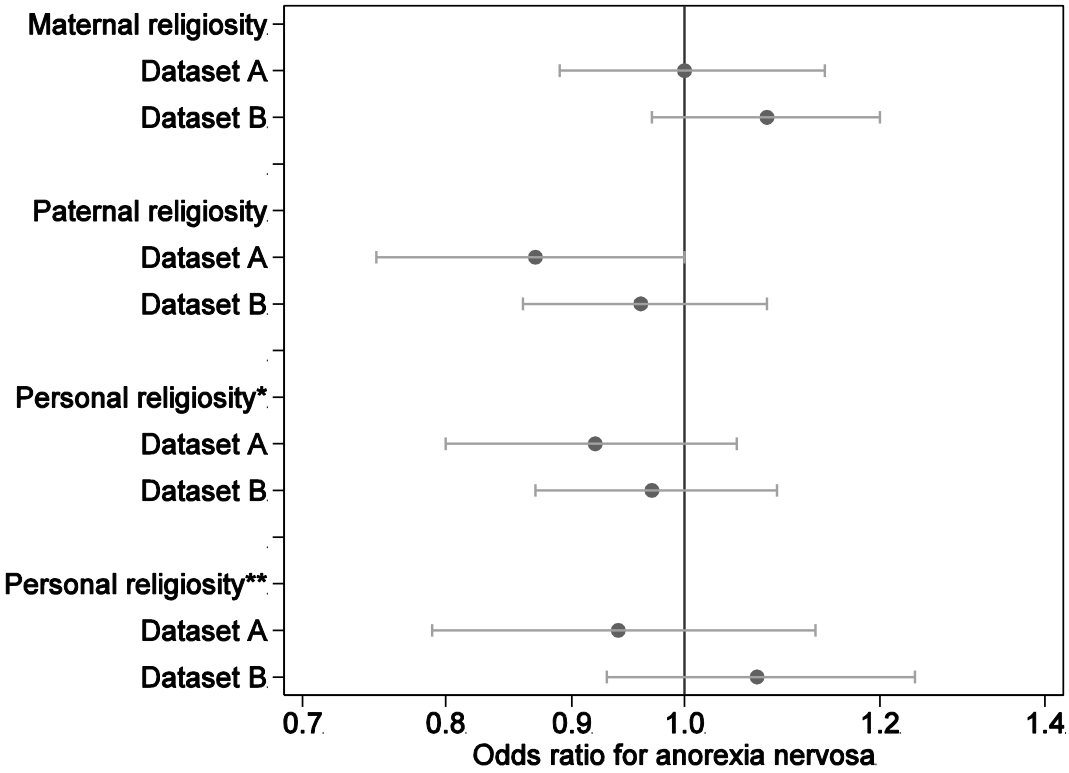


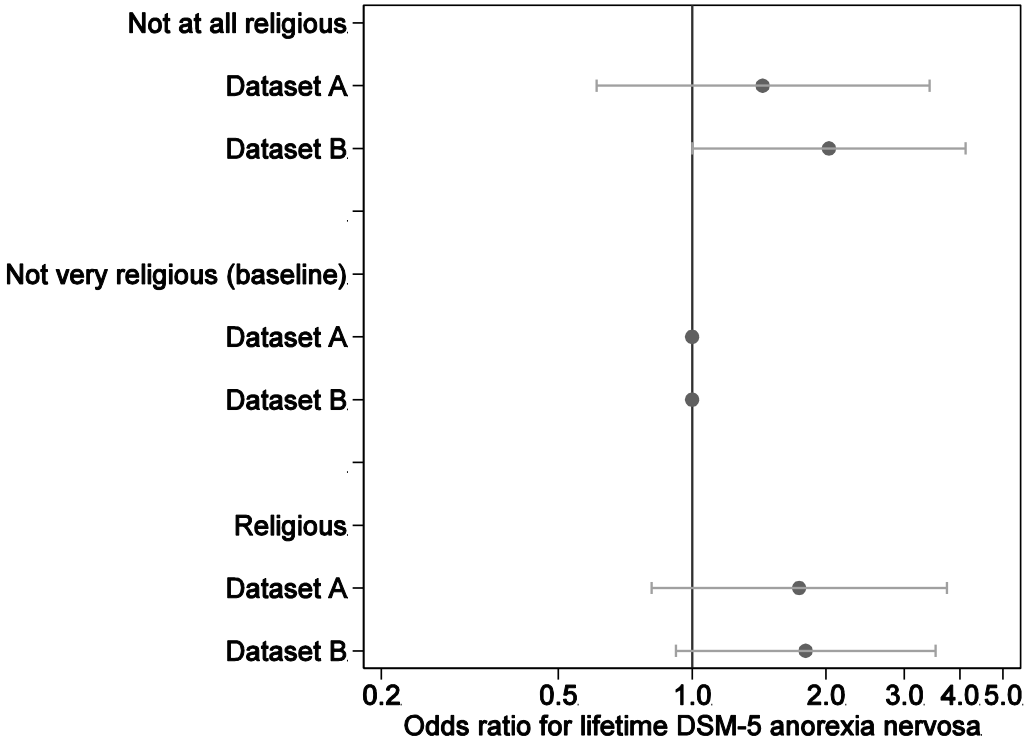
Figure 2. Odds ratios for lifetime DSM-5 anorexia nervosa by unit increase in religiosity. Religiosity measured on the Religious fundamentalism content scale of the Minnesota Multiphasic Personality Inventory when the women were 16 year adolescents.



Legend: *Personal religiosity in adolescence; **Personal religiosity in adolescence with anorexia nervosa onset after the measurement of religiosity; the bars mark the 95% confidence intervals. Odds ratios are on a logarithmic scale. The analyses are based on 1312 women (38 had anorexia nervosa) in Dataset A and 1327 women (53 had anorexia nervosa) in dataset B. The analyses of anorexia nervosa onset after the measurement of religiosity are based on 1297 women (23 had

anorexia nervosa) in dataset A and 1303 women (29 had anorexia nervosa) in dataset B.

Figure 3. Odds ratios for lifetime DSM-5 anorexia nervosa by religiosity in early adulthood (when the women were 22–27 years old). The 'not very religious' category is the reference (odds ratio = 1).



Legend: The bars mark the 95% confidence intervals. Odds ratios are on a logarithmic scale. The analyses are based on 1312 women (38 had anorexia nervosa) in Dataset A and 1327 women (53 had anorexia nervosa) in dataset B. The estimated proportions of women having anorexia nervosa in datasets A and B were as follows: among not at all religious 3.2% and 5.5%, among not very religious 2.2% and 2.8% and among religious 3.8% and 4.9%.

Acknowledgements/Disclosure of Conflicts

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Supplemental Materials: For Online Publication Only

Appendix A

The 12-item Religious fundamentalism content scale of the Minnesota Multiphasic Personality Inventory (MMPI).

1. Everything is turning out just like the prophets of the Bible said it would
2. I go to church almost every week
3. I believe in the second coming of Christ
4. I believe in a life hereafter
5. I am very religious (more than most people)
6. I believe there is a Devil and Hell in the afterlife
7. I believe there is a God
8. I feel sure that there is only one true religion
9. Christ performed miracles such as changing water into wine
10. I pray several times a week
11. I read the Bible several times a week
12. I have no patience with people who believe there is only one true religion

Legend: For items 1–11, endorsing 'True' is scored 1 and endorsing 'False' is scored 0. Item 12 is reversed ('True' is scored 0 and 'False' is scored 1). The score for the 12-item Religious fundamentalism content scale is the sum of scores for items 1–12.

Wording from: Winter T, Kaprio J, Viken RJ, Karvonen S, Rose RJ. Individual differences in adolescent religiosity in Finland: familial effects are modified by sex and region of residence. Twin Res. 1999;2(2):108-114.

Appendix B

Detailed description of the datasets, multiple imputation and auxiliary religiosity measures.

Datasets

Because our data consists of twin pairs, the observations concerning twin individuals are not independent of each other. Therefore, we divided each twin pair to two separate datasets. Individuals with even id numbers were assigned to dataset A and individuals with odd id numbers were assigned to dataset B. The internal id numbers were assigned prior to data collection. This resulted in two datasets that consist of independent observations. However, the datasets are not independent of each other, and fathers and mothers of complete twin pairs belong to both datasets.

We excluded from both datasets women with missing information on lifetime DSM-5 anorexia nervosa status, because they were the women who could be considered neither healthy nor affected by anorexia nervosa. We also excluded the few women living on the Åland Islands[38]. After these exclusions, dataset A consisted of 1312 women of whom 38 had a diagnosis of lifetime DSM-

5 anorexia nervosa, and dataset B consisted of 1327 women of whom 53 with lifetime DSM-5 anorexia nervosa. The analyses of DSM-5 anorexia nervosa with age of onset after 16 years were based on 1297 women and 23 anorexia nervosa cases in dataset A and 1303 women and 29 anorexia nervosa cases in dataset B.

Before multiple imputation, we had a high percentage (94–95%) of complete information from the single question on personal religiosity in early adulthood. The percentage of complete information was lower from religiosity in adolescence and from religiosity of parents (59–70%). Complete information for all the variables used in the multiple imputation was available from 22–28% of women in our datasets.

Multiple imputation

We used Substantive-model compatible fully conditional specification (SMC-FCS) multiple imputation to impute missing covariates for main analyses[49,50]. In the SMC-FCS, we modeled discrete (e.g. religiosity in wave 1) and categorical variables with ordered logistic regression and binary variables with logistic regression. To account for possible non-linear effects, we also examined

substantive models with quadratic effects of the religiosity variables from wave 1, and found that their fit was not significantly better from linear models.

In multiple imputation, we used information on all relevant variables: personal, maternal and paternal religiosity at wave 1, personal religiosity at wave 4, place of residence at wave 1, education at wave 4 and lifetime anorexia nervosa status (with or without information on age of onset). We also included interactions between religiosity variables in wave 1 and place of residence in wave 1. To improve the quality of multiple imputation, we used two auxiliary multiple-choice items from wave 4: church going frequency and the importance of the religiosity of partner and peers. Church going frequency ("Not counting weddings, funerals and baptism how often do you go to church or other religious events?") had five response alternatives: 1) once a week, 2) once a month, 3) once a year, 4) less often and 5) not at all. We merged categories 1) and 2) because of few responses in them. The importance of the religiosity of the partner and peers ("How important to you is the religious faith of your girl-/boyfriend or the faith of your close friends?") similarly had five response alternatives: 1) very important, 2) important, 3) not very important, 4) not at all important and 5) cannot say. We considered category 5) missing information.

We performed multiple imputation separately for each dataset to impute the missing values. To ensure compatibility with the substantive model, we based analyses on the two different outcomes (lifetime anorexia nervosa and anorexia nervosa with age of onset >16 years) on separate multiple imputation models with separate substantive models. To achieve low Monte Carlo errors, we used 200 imputations per multiple imputation model. Further, to ensure proper convergence of the chained equations, we used 100 burn in iterations for each imputation. The adequacy of the multiple imputation was checked by comparing the distributions of the observed and imputed values, by graphically checking the convergence of the burn in iterations and by checking the Monte Carlo errors as recommended by White et al[52].

Additional analyses concerning currently symptomatic women, place of residence in early adulthood and EDI-2 subscales[41] in early adulthood were based on complete cases after stepwise deletion in datasets A and B because of sparse data or limited number of substantive models supported by the SMC-FCS multiple imputation statistical package. However, there were only few missing information in these analyses. Complete information was available from 97–99% of women for place of residence and EDI-2 subscales and from 94–95% of women

for religiosity in early adulthood. Information on current symptoms was complete for those with lifetime DSM-5 anorexia nervosa.

Aggregate measure of religiosity in early adulthood

In early adulthood, we used information from all relevant variables to construct an aggregate measure of religiosity. These were scored as follows: religiosity "religious" (3), "not very religious" (2), and "not at all religious"(1); church going frequency "once a week or once a month" (4), "once a year" (3), "less often" (2) and "not at all" (1); the importance of the religiosity of the partner and peers "very important (4)", "important" (3), "not very important" (2) and "not at all important" (1). We summed up the scores from all these three variables to yield an aggregate measure of religiosity that ranged from 3 to 11. The Cronbach's alphas were 0.77–0.78 among the complete cases in datasets A and B.

Tertiles of religiosity and change in religiosity

To assess change in personal religiosity between study waves, we used tertile splits of religiosity both in adolescence and in early adulthood.

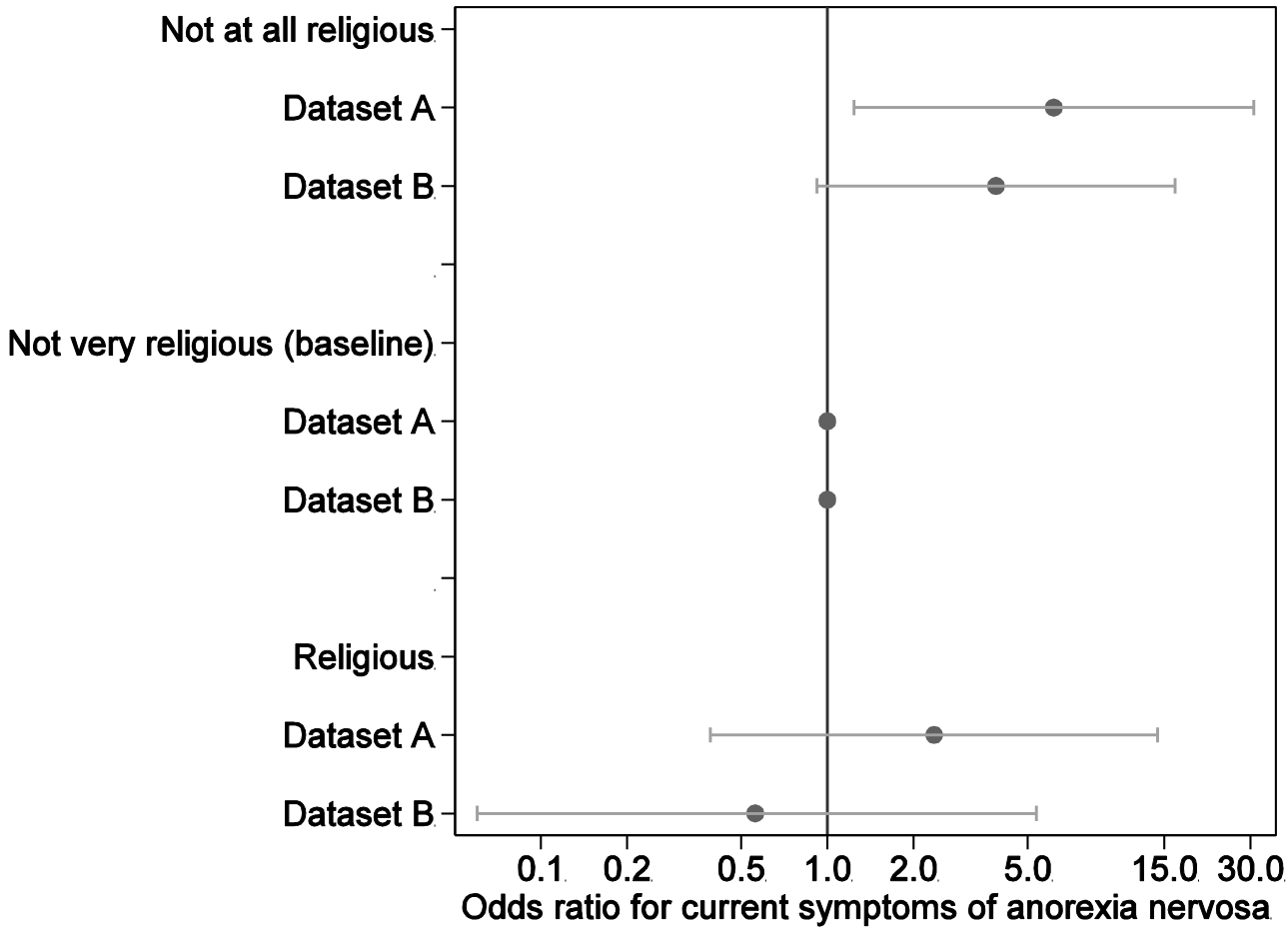
In adolescence, we simply split the Religious fundamentalism content scale of the Minnesota Multiphasic Personality Inventory[37,38] (Appendix 1) into tertiles. In early adulthood, we split the aggregate measure of religiosity into tertiles.

Women who were in the same tertile of religiosity in both study waves were defined to be a reference group. Others were divided to those with increasing and decreasing religiosity. Then, we used multinomial logistic regression to calculate relative-risk ratios for increasing and decreasing religiosity between the study waves by lifetime DSM-5 anorexia nervosa status.

References for Appendix B

Please see the corresponding reference numbers in the main text.

Appendix C. Odds ratios for current symptoms of anorexia nervosa* in early adulthood by religiosity in early adulthood.



Legend: *Currently symptomatic women compared to healthy women. Early adulthood when the women were 22–27 years old. The bars mark the 95% confidence intervals. Odds ratios are on a logarithmic scale. The numbers were as follows (in Datasets A and B, respectively): 281 and 260 not at all religious (6 and 5 of whom had current symptoms), 568 and 596 not very religious (2 and 3 of

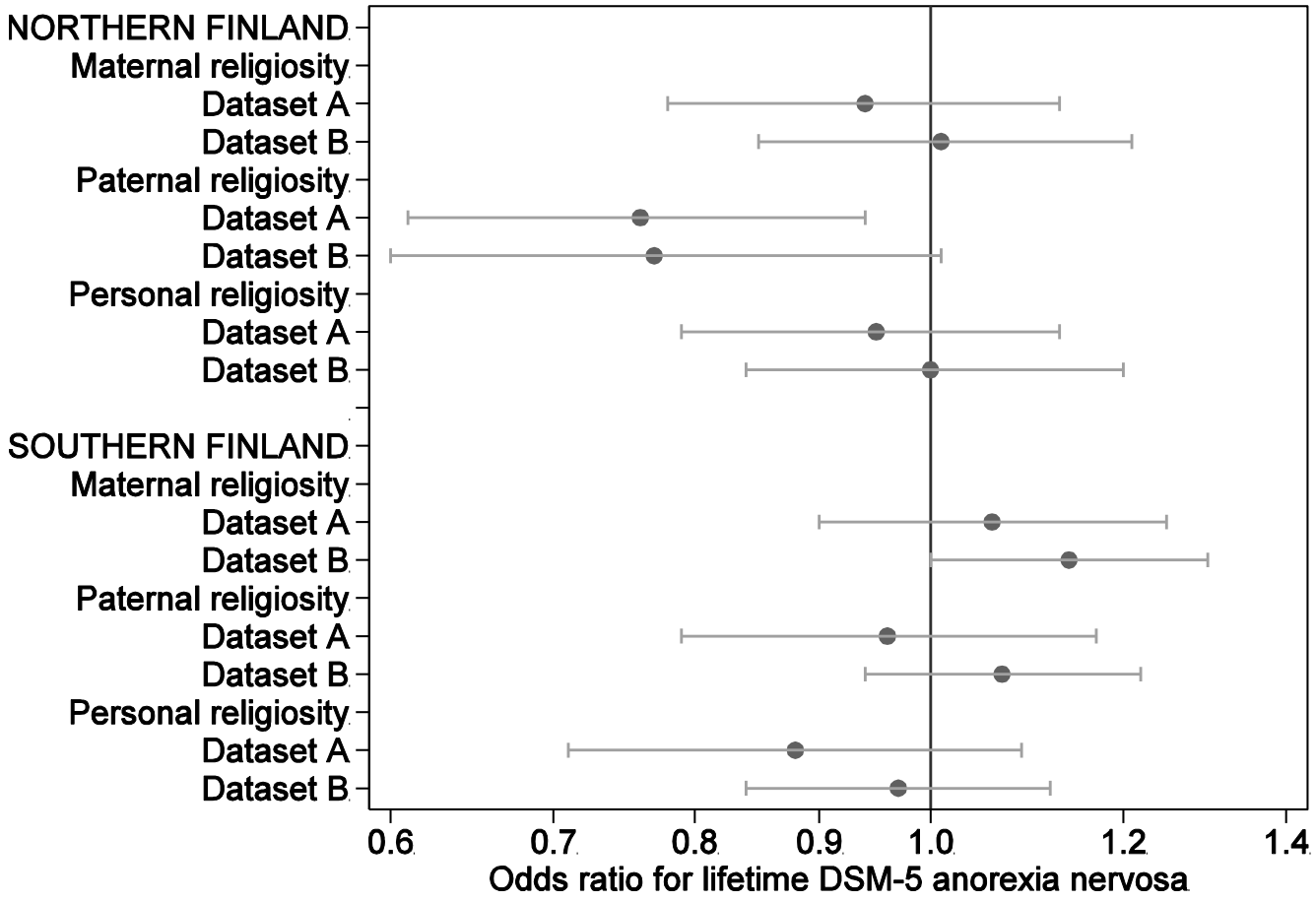
whom had current symptoms) and 362 and 357 religious (3 and 1 of whom had current symptoms).

Appendix D. Odds ratios for current symptoms of anorexia nervosa* in early adulthood by unit increase in religiosity in adolescence.

Dataset A					
	N total	N anorexia nervosa	OR	95% CI	p-value
Religiosity in adolescence	895	8	0.69	0.48–0.98	0.04
Dataset B					
	N total	N anorexia nervosa	OR	95% CI	p-value
Religiosity in adolescence	905	8	0.80	0.59–1.09	0.16

Legend: *Currently symptomatic women compared to healthy women. Early adulthood when the women were 22–27 years old. Adolescence when the women were 16 years old. OR, odds ratio; 95% CI, 95% confidence interval.

Appendix E. Odds ratios for lifetime DSM-5 anorexia nervosa in Northern and Southern Finland by unit increase in religiosity. Religiosity measured on the Religious fundamentalism content scale of the Minnesota Multiphasic Personality Inventory when the women were 16 year adolescents.

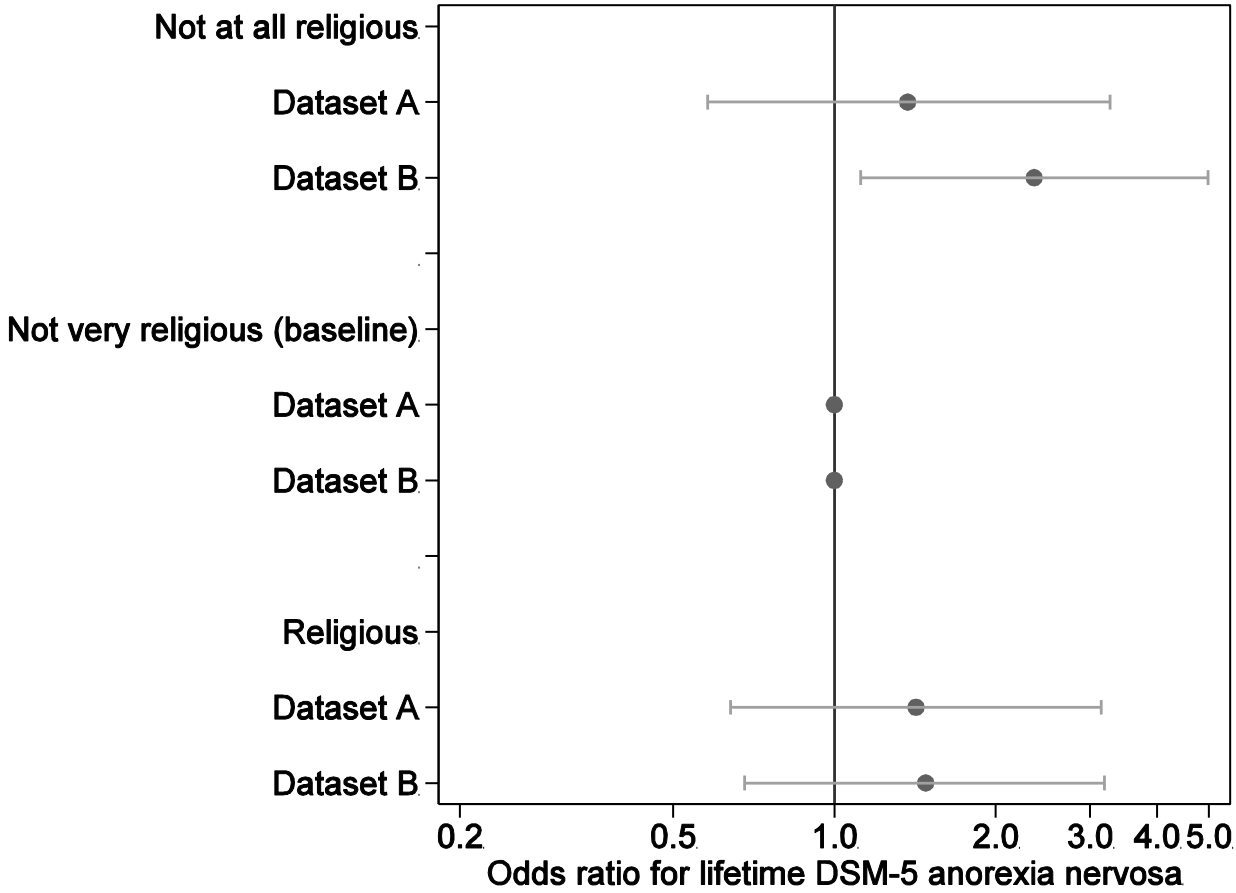


Legend: The bars mark the 95% confidence intervals. Odds ratios are on a logarithmic scale. The analyses are based on 1312 women (38 had anorexia nervosa) in Dataset A and 1327 women (53 had anorexia nervosa) in dataset B.

1 The estimated proportions living in Northern and Southern Finland were 44%

2 and 56% in both datasets.

Appendix F. Odds ratios for lifetime DSM-5 anorexia nervosa by religiosity (not very religious being the reference group) in early adulthood (when the women were 22–27 years old). Analysis restricted to urban areas.

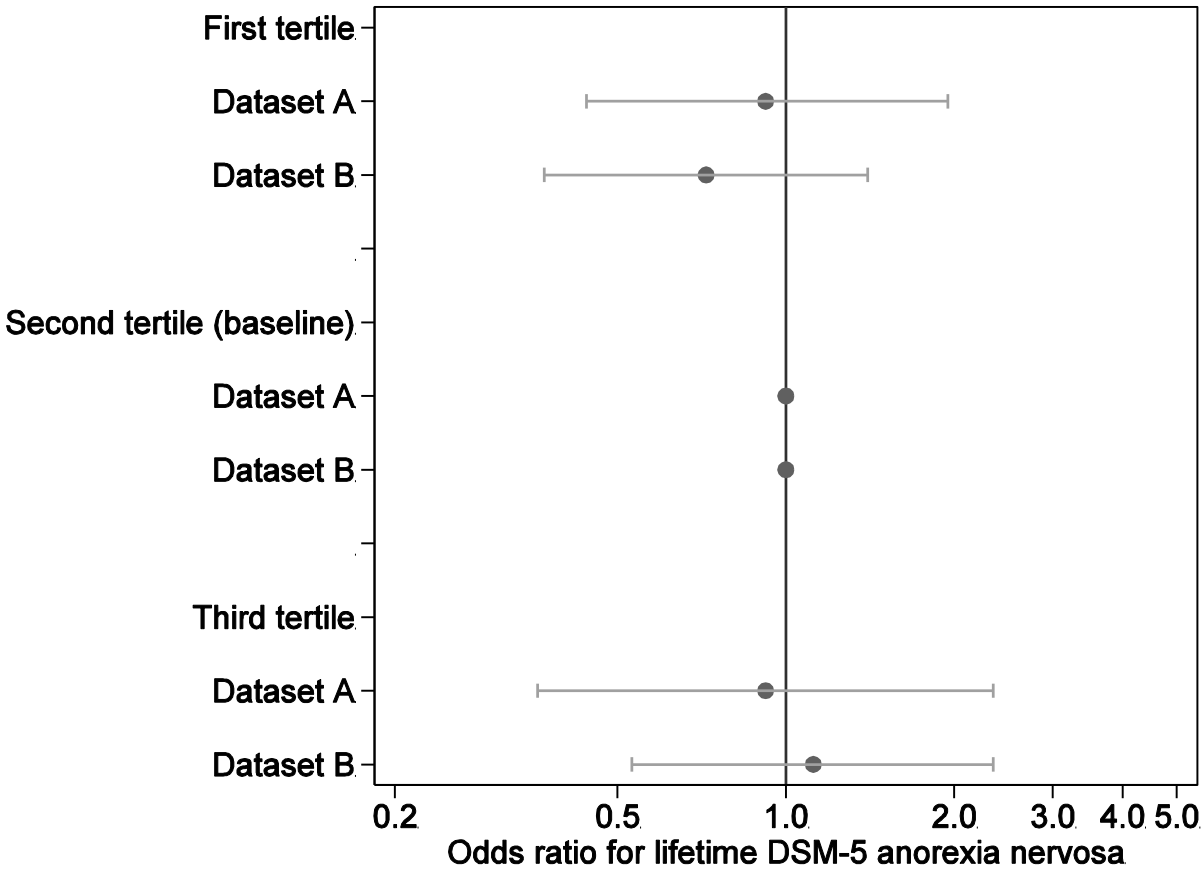


Legend: The bars mark the 95% confidence intervals. Odds ratios are on a logarithmic scale. The number were as follows (in Datasets A and B, respectively): 221 and 210 not at all religious (9 and 15 of whom had anorexia

1 nervosa), 434 and 443 not very religious (13 and 14 of whom had anorexia

2 nervosa) and 286 and 283 religious (12 and 13 of whom had anorexia nervosa).

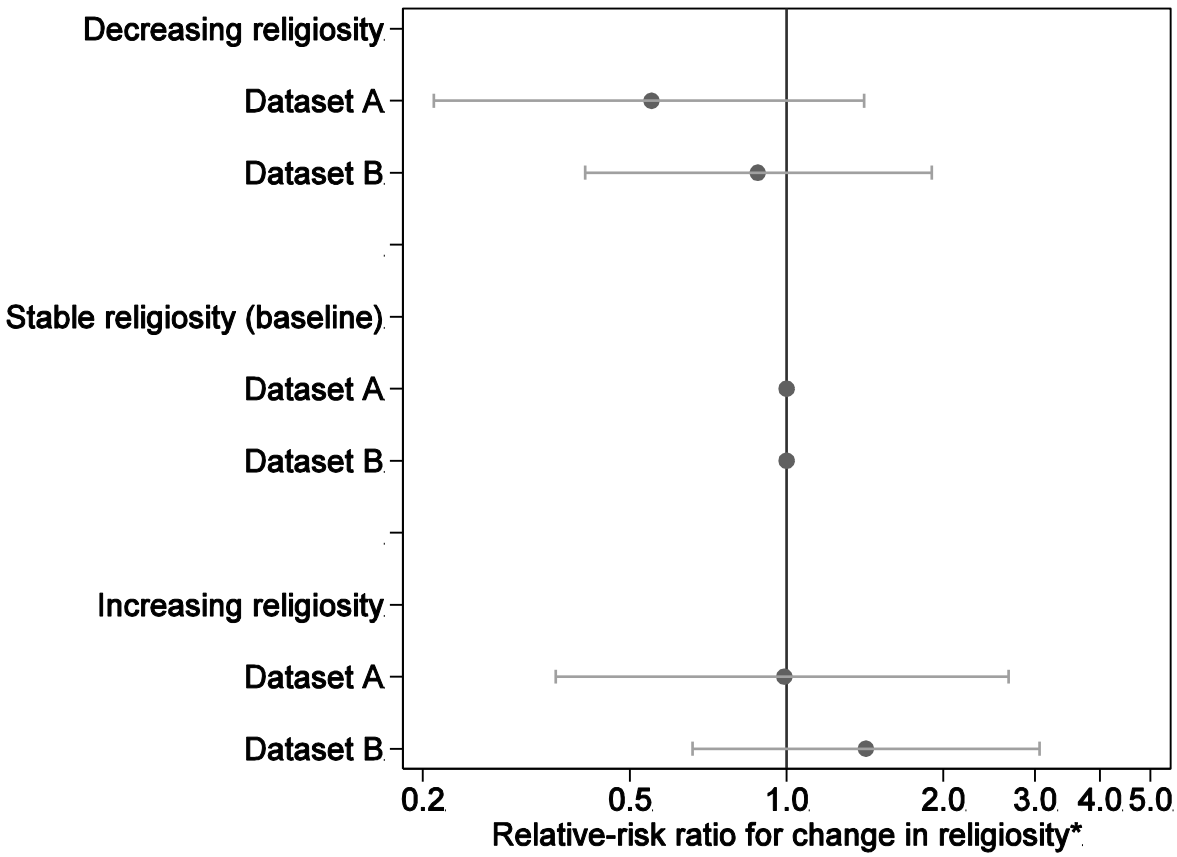
Appendix G. Odds ratios for lifetime DSM-5 anorexia nervosa by tertiles of religiosity in early adulthood (when the women were 22–27 years old).



Legend: The bars mark the 95% confidence intervals. Odds ratios are on a logarithmic scale. The analyses are based on 1312 women (38 had anorexia nervosa) in Dataset A and 1327 women (53 had anorexia nervosa) in dataset B. The estimated proportions of women having anorexia nervosa in datasets A and B were as follows: among the first tertile (least religious) 2.8% and 3.3%, among

the second tertile (baseline) 3.1% and 4.5%, and among the third tertile (most religious) 2.8% and 5.0%.

Appendix H. Relative-risk ratios for decreasing and increasing religiosity between study waves for those with lifetime DSM-5 anorexia nervosa (when compared to healthy women)



Legend: *Relative-risk ratios are for those with lifetime DSM-5 anorexia nervosa when compared to healthy women. The bars mark the 95% confidence intervals. Relative-risk ratios are on a logarithmic scale. The analyses are based on 1312 women (38 had anorexia nervosa) in Dataset A and 1327 women (53 had anorexia nervosa) in dataset B. The estimated proportions of women having

anorexia nervosa in datasets A and B were as follows: among those with decreasing religiosity 1.9% and 3.4%, among those with stable religiosity 3.3% and 3.8%, and among those with increasing religiosity 3.3% and 5.4%.